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TRIGONALYIDAE (HYMENOPTERA) IN THE EASTERN UNITED STATES: SEASONAL FLIGHT ACTIVITY, DISTRIBUTIONS, HOSTS

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Abstract.—Three of the four Nearctic species of Trigonalyidae occur in the eastern United States, *Orthogonalys pulchella* (Cresson), *Taeniogonalos gundlachii* (Cresson) (= *Poecilogonalos costalis* (Cresson)), and *Lycogaster pullata* Shuckard. Seasonal flight data is determined from collections of 4272 specimens from eight study sites in Maryland, Virginia, and West Virginia. *Orthogonalys pulchella* and *T. gundlachii* flights begin in mid-May and peak in June and the first of July, but both species are present in low numbers through the first of October. The flight period of *L. pullata* could not be determined. Identification, distributions, hosts, and habitats are reviewed for each species.

Key Words: Trigonalyidae, Trigonalidae, parasitoids, North America, seasonal activity, distributions, hosts

Trigonalyidae (= Trigonalidae) are parasitoids of ichneumonid and tachinid parasitoids of Lepidoptera and Diptera and parasitoids of social wasps. In Australia, they have been recorded as primary parasitoids of sawflies (Raff 1934, Carne 1969). Their life cycle is complex and precarious for survival. Thousands of eggs are deposited on leaves by each female. Further development is dependent not only on a caterpillar ingesting the eggs with the leaves but also dependent on an already parasitized caterpillar ingesting the eggs. The trigonalyid then develops on the parasitoid of the caterpillar. Trigonalyids do not develop if ingested by a non-parasitized caterpillar, though the trigonalyid immature may remain viable in case the caterpiller is later parasitized. For those that develop on wasps, a caterpillar that has ingested the eggs must be taken as prey by the wasp back to the larvae in its nest. A general account of the known biology of trigonalyids is given by Clausen (1931, 1940), with more recent and complete summaries by Weinstein and Austin (1991) and Carmean (1991).

There are four Nearctic species of Trigonalyidae. *Orthogonalys pulchella* (Cresson) and *Taeniogonalos gundlachii* (Cresson) occur in eastern North America; *Lycogaster pullata* Shuckard is transcontinental; and *Bareogonalos canadensis* (Harrington), a parasitoid of Vespidae, is western. I have collected all three eastern species during 13 years of trapping at eight sites in Virginia, Maryland, and West Virginia, though concentrated collecting has been done only from 1987 through 1994, and have accumulated seasonal flight information based on collections of 4272 specimens. This is probably one of the largest collections of this family, which was once considered very rare and was scarce in collections. Here, I give an identification guide to the three species, outline

their seasonal flight activity in the mid-Atlantic states, and review distribution, host, and habitat data.

Materials and Methods

Collections were by Townes-style Malaise traps (Townes 1972), using 95% ethyl alcohol as a killing agent. Dry collecting heads using cyanide were used only in Green Ridge State Park, Allegany Co., Maryland. Traps were in operation from the first of March or April through September to mid-November, depending on the site. They were serviced about every ten days to three weeks, depending on the weather and time of season. Collections were made from eight sites in Maryland, Virginia, and West Virginia from the coastal plain (Essex Co., Va.) to the Appalachians (Tucker Co., W. Va., and Allegany Co., Md.), from 1983 through 1994 (see specimens examined sections for localities and years of operation). One trap was used at the Fairfax Co., Virginia, site (back yard trap). Two traps were used at the Hardy Co., West Virginia, site. Four to 20 traps were used per year at each of the other sites, the number differing from year to year at some sites. The traps were placed in different habitats on the sites which ranged from less than 100 to more than 600 acres in size. Sawflies (Symphyta) were the target groups for my collections; consequently, most traps were placed in situations where I would expect to obtain the largest numbers and greatest diversity of these groups. Good sawfly habitats also proved productive for Trigonalyidae.

Townes' (1956) revision of the Nearctic species is still useful. No additional species have been found. References to original descriptions and synonyms may be found in Townes (1956) and Carlson (1979). A current classification of the world Trigonalyidae by Carmean and Kimsey is in press.

Specimens used in this study are deposited in the National Museum of Natural History, Washington, D.C.

Identification

The four Nearctic species were separated by Townes (1956) by morphological characters. However, the eastern species are readily separated by color and habitus. The following simplified key and the accompanying illustrations will separate them.

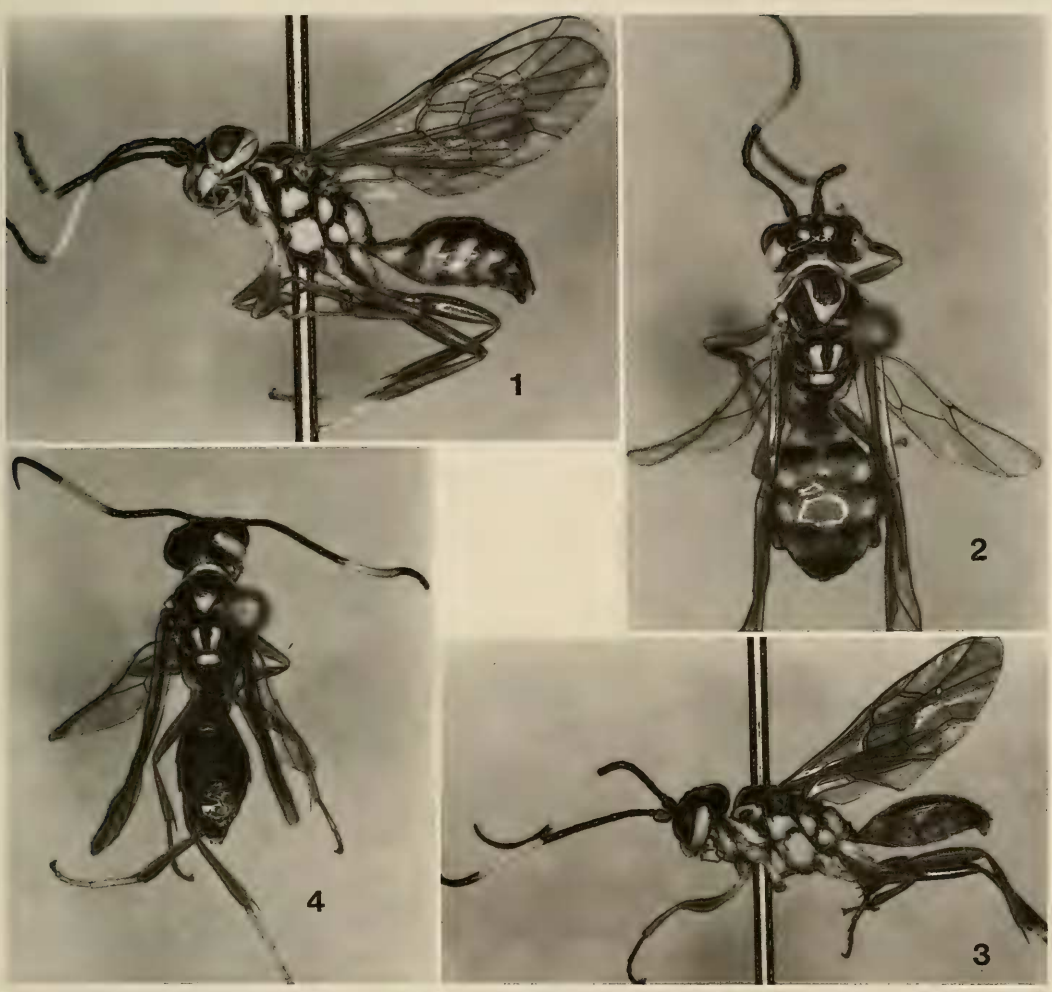
1. Antenna with a white band; black with considerable yellowish to orange markings; ichneumonid-like in appearance (Figs. 1–4) . . . . . *Orthogonalys pulchella* (Cresson)
– Antenna black; black or mostly black with yellow marks; wasp-like in appearance (Figs. 5–12) 2
2. Black, with several transverse yellow lines on abdominal terga only; antenna thickened (Figs. 9–12); forewing uniformly hyaline to slightly darkened . . . . . *Lycogaster pullata* Shuckard
– Black with yellow marks behind eyes, on mesopleuron, mesoprescutum, mesoscutellum, and solid transverse stripes on abdomen; antenna slender (Figs. 5–8); dorsoapical portion of forewing infuscated . . . . . *Taeniogonalos gundlachii* (Cresson)

Orthogonalys pulchella (Cresson) (Figs. 1–4, 13–15)

This is by far the most common trigonalyid in eastern North America. Specimens were common at most of my collecting sites. The size is extremely variable, ranging from about 5 to 12 mm in length.

Distribution.—Connecticut, District of Columbia, Maine, Maryland, New Jersey, New York, Pennsylvania, Rhode Island, Virginia, West Virginia.

Specimens examined.—Total: 3827. MARYLAND: Allegany Co., Green Ridge State Park (61; 1992–1993); Prince Georges Co., Beltsville Agricultural Research Center (291; 1991–1993). VIRGINIA: Clarke Co., University of Virginia Blandy Experimental Farm, 2 mi. S. Boyce (1947; 1990–1994); Essex Co., 1 mi. SE Dunnsville (729; 1991–1994); Fairfax Co., near Annandale (20; 1983–1994); Louisa Co., 4 mi S. Cuckoo (704; 1987–1989). WEST VIRGINIA: Hardy Co., 3 mi. NE Mathias (22; 1994); Tucker Co., Fernow Experimental Forest, 3 mi S. Parsons (26; 1991–1993).



Figs. 1–4. *Orthogonalys pulchella.* 1, Female, lateral. 2, Female, dorsal. 3, Male, lateral. 4, Male, dorsal. Length, ca. 9 mm.

Hosts.—Known only from tachinid parasitoids of Lepidoptera caterpillars: *Archytas aterrimus* (Robineau-Desvoidy) (Tachinidae) (Carlson, 1979). Records citing parasitism of *Nilea lobeliae* (Tachinidae) in *Acronicta lobeliae* are incorrect (Carmean and Kimsey, in press) (see *T. gundlachii*). A specimen from Connecticut is labeled "ex *Ellopia athasaria*" (Geometridae).

Flight records.—Townes (1956) reported that males occur mostly in June and early July with extreme dates of May 25 and July 21, and that females occur mostly from mid-June to mid-August, with extreme dates of June 7 and August 23.

I collected this species from the middle third of May through the first part of October (Figs. 13–15). The peak flight is in June, with the greatest number of specimens during the middle third of June. The species is present in low numbers through the rest of the season, but there is a low peak during the last third of August through the first third of September. The climb to the peak flight in June and the decline after June are very abrupt. The peak flight in Essex Co., the most southern site, is the first third of June (Fig. 13), whereas the peak flight at more northern localities is mid-June, as at the Clarke Co. site (Fig. 14). It

is very numerous during the peak flight time in June. As many as 92 specimens were taken in one trap in Clarke Co., June 8–18, 1991, and 114 specimens June 15–24, 1994, and 123 specimens were in a single trap in Louisa Co., June 8–18, 1988.

Habitats.—Townes (1956) reported that this species is most common in damp, rich woodlands where they occur on the foliage at about the 35-cm level. They crawl over the foliage or take short flights. In size, coloration, and movements, they mimic several species of ichneumonids and sawflies that are common in the same habitats.

I have caught specimens in almost every habitat where I have set traps, but they are by far most common within woodlands and damp, bottomland woods. At the Beltsville Agricultural Research Center, where traps were set in four different habitats, most (274 of the 291 specimens) were collected in a bottomland deciduous forest trap. In Clarke Co., most were collected within a 40 acre, 90-year-old, oak-elm-hickory woodlot in traps set at the forest edge and within the forest. In 1994, four traps were used in the woodlot and four nearly a mile away in open shrubby areas around ponds and near fields. Of the 498 specimens collected, 482 were in the woodlot. At Green Ridge State Park, most specimens (53) were collected in two traps located in a bottomland forest near a stream with very few (8) in four traps set in openings or semi-openings on an adjacent shale barren ridge. In Hardy Co., West Virginia, all 22 specimens were from a trap by a stream in the woods; none were in a trap in a clearing on a ridge about 100 yards away.

Taeniogonalos gundlachii (Cresson)
(Figs. 5–8, 16)

This is the second most commonly collected species of Trigonalyidae. It was most common at my most southern collecting site (Essex Co.). None were taken at the most western sites in western Maryland and Tucker Co., West Virginia. Specimens ranged from 5 mm to 11 mm in length. Most literature references to this species are under the name *Poecilogonalos costalis* (Cresson). Carmean and Kimsey (in press) dealt with the taxonomy of this species, and all changes and synonymies should be attributed to them.

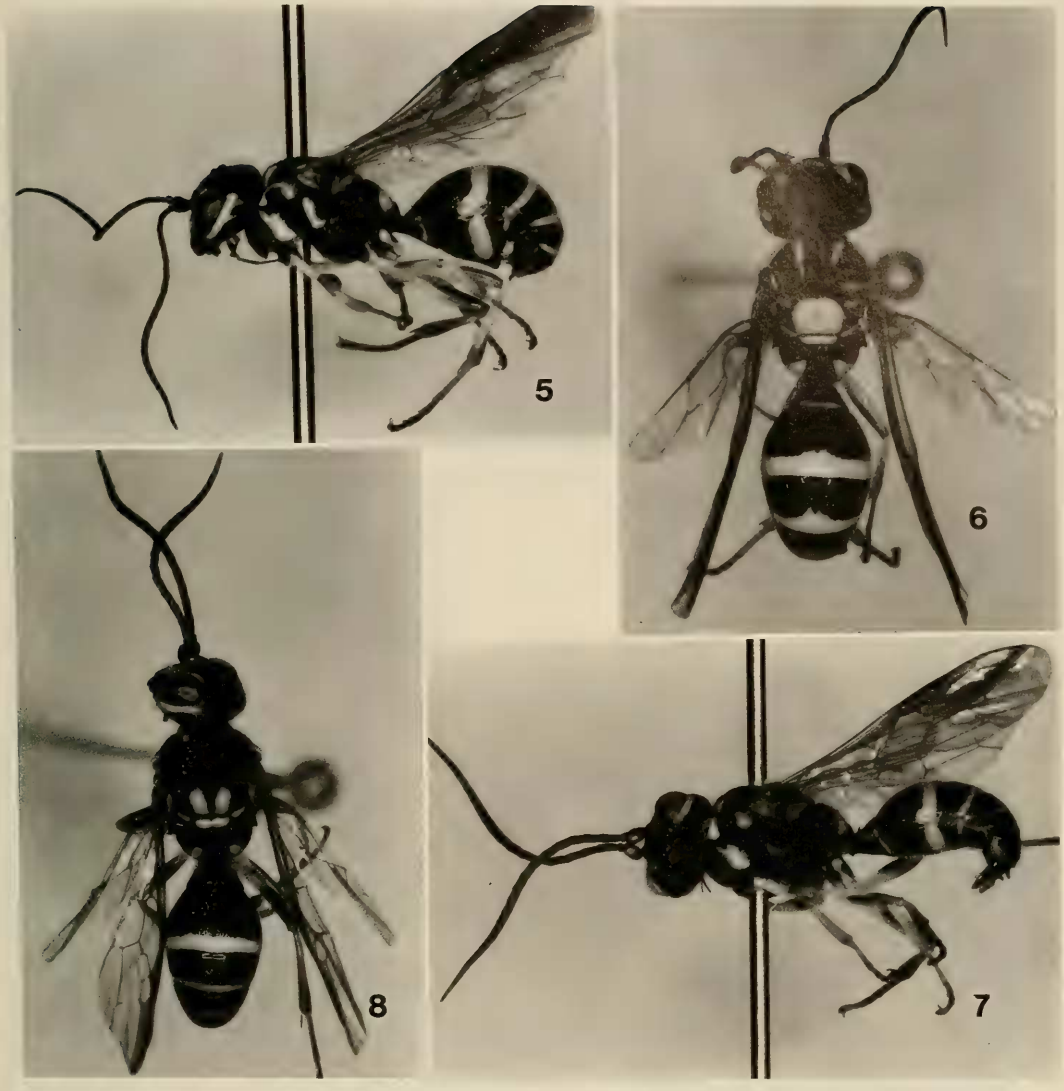
Distribution.—Connecticut, Florida, Kansas, Louisiana, Maryland, Massachusetts, New Jersey, New York, North Carolina, Ohio, Pennsylvania, South Carolina, Texas, Virginia, West Virginia; Cuba.

Specimens examined.—Total: 440. MARYLAND: Prince George's Co., Beltsville Agricultural Research Center (46; 1991–1993). VIRGINIA: Clarke Co., University of Virginia Blandy Experimental Farm, 2 mi. S. Boyce (29; 1990–1994); Essex Co., 1 mi. SE Dunnsville (252; 1991–1994); Fairfax Co., near Annandale (11; 1983–1994); Louisa Co., 4 mi. S. Cuckoo (99; 1987–1989). WEST VIRGINIA: Hardy Co., 3 mi. NE Mathias (3; 1994).

Hosts.—Known only from tachinid parasitoids of Lepidoptera caterpillars and one record from a tipulid larva: *Lespesia* sp. (Tachinidae) ex *Phosphila turbulenta* Huebner (Noctuidae); reared as a secondary parasitoid of *Automeris io* (F.) (Saturniidae) (Carlson 1979); from *Nilea lobeliae* (Coquillett) (Tachinidae) parasitizing *Acronicta lobeliae* Guenée (Noctuidae) (Riley and Howard 1891); reared from a puparium of *Allophorocera arator* (Aldrich) (Tachinidae) which parasitized a larva of *Tipula* (*Triplicitipula*) sp., probably *flavoumbrosa* Alexander (Tipulidae) (Gelhaus 1987). Labels on specimens I have examined are as follows: "ex *Symmerista albifrons* [Notodontidae]" (from Connecticut); ex *Hadena turbulenta* [Noctuidae]" (from Massachusetts); "ex larva on *Quercus,* host: *Anisota discolor* [Saturniidae]" (from Texas); and "ex *Macrurocampa marthesia* [Notodontidae] on oak" (from West Virginia).

Flight records.—Townes (1956) reported that most collection dates were from June 25 through August 4, with extreme dates of June 10 and September 6.

I have collected this species from mid-May through the first week in October (Fig.



Figs. 5–8. *Taeniogonalos gundlachii.* 5, Female, lateral. 6, Female, dorsal. 7, Male, lateral. 8, Male, dorsal. Length, ca. 9 mm.

16). The peak flight is from mid-June through the first third of July, slightly later than the peak flight of *O. pulchella.* However, similar to *O. pulchella,* they are present in low numbers through the rest of the season into October, and there is a very low peak from the end of August through the first third of September. Collection records show a gradual increase in numbers from the last of May to the peak during the first third of July, unlike the more abrupt rise of *O. pulchella.* Of the 440 specimens, 341 were collected from the middle third of June through the middle third of July.

Habitats.—Townes (1956) reported this species in partially sunlit openings of rich woods with abundant undergrowth, at the 20- to 40-cm level. I have collected specimens in most traps from various habitats. It is not collected in large number like *O. pulchella,* and the species appears to be more generally distributed than *O. pulchella.* At the Beltsville

Figs. 9–12. *Lycogaster pullata.* 9, Female, lateral. 10, Female, dorsal. 11, Male, lateral. 12, Male, dorsal. Length, ca. 10 mm.

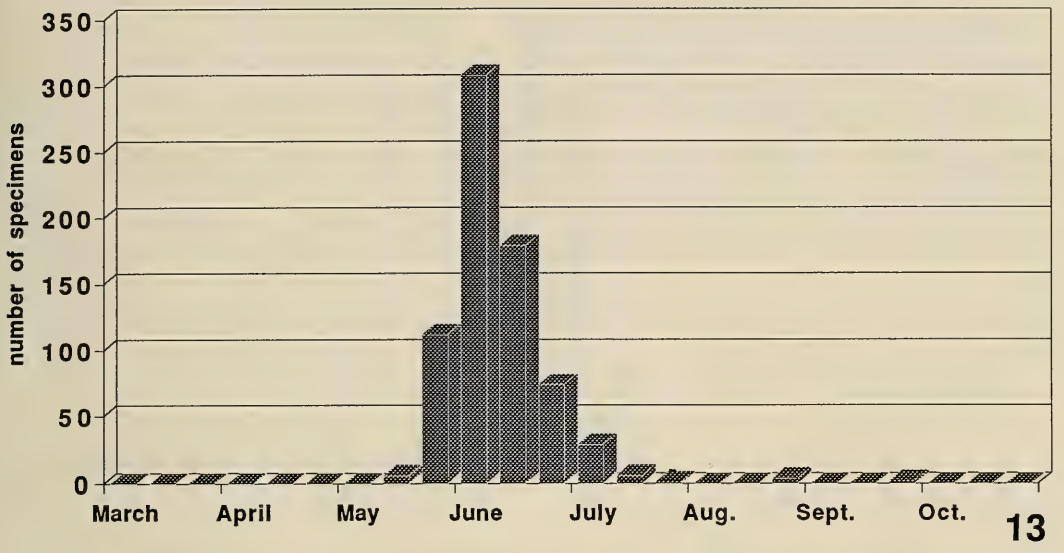
Agricultural Research Center as many or more specimens were in open or semi-open traps (34 in 3 traps) as in those in more shaded woodlands (12 in 1 trap in a bottomland deciduous forest). The same is true for collections in Clarke and Essex counties.

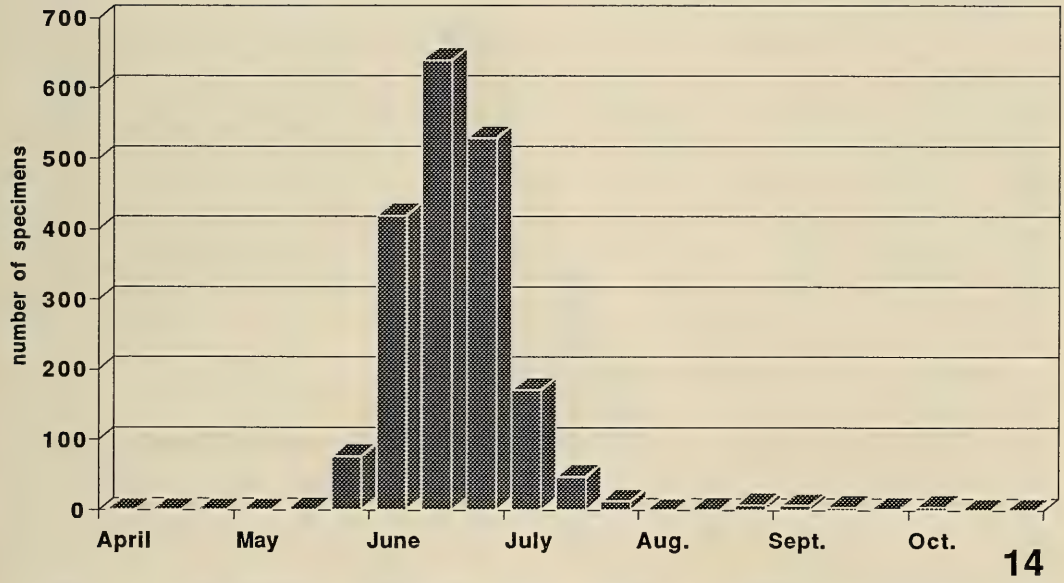
Lycogaster pullata Shuckard
(Figs. 9–12)

I collected only 5 specimens of this species. The species is sometimes divided into eastern and western subspecies, *L. pullata pullata* in the East and *L. pullata nevadensis* (Cresson) from Colorado and New Mexico westward.

Distribution.—In eastern United States: District of Columbia, Georgia, Maryland, Massachusetts, Michigan, Minnesota, New York, North Carolina, North Dakota, Pennsylvania, Rhode Island, Vermont, Virginia.

Specimens examined.—Total: 5. MARYLAND: Allegany Co., Green Ridge State



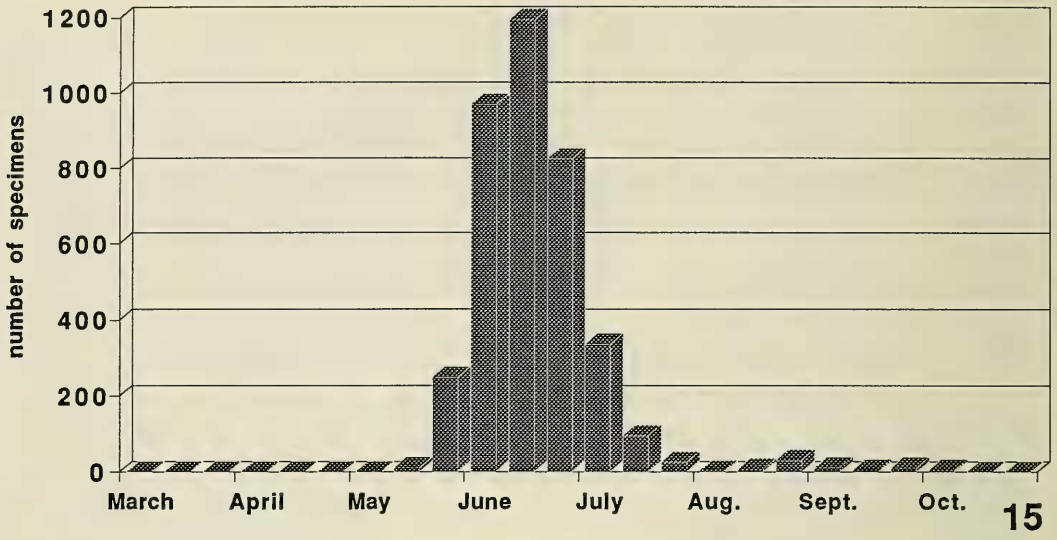


Figs. 13, 14. Flight records of *Orthogonalys pulchella.* 13, Essex Co., Virginia, 1991–1994. Traps in operation from the first of March through October. 14, Clarke Co. Virginia, 1990–1994. Traps in operation from the first of April through October.

Park (2; 1992–1993). VIRGINIA: Essex Co., 1 mi. SE Dunnsville (3; 1991–1994).

Hosts.—Known from caterpillar-provisioning eumenine wasps and from ichneumonid parasitoids of caterpillars: *Euodynerus foraminiatus foraminiatus* (Saussure) (Eumenidae) (Cooper, 1954); *Enicospilus americanus* (Christ) (Ichneumonidae) ex *Antheraea polyphemus* (Cram.) (Saturniidae) (Bischoff 1909, Townes 1956). From *Hyphantria cunea* (Drury) (Arctiidae) in Colorado (Townes 1956).

Flight records.—Townes (1956) reported dates of collection in June and July with extreme dates of May 9 and August 25. Collection dates in Essex Co. are May 25



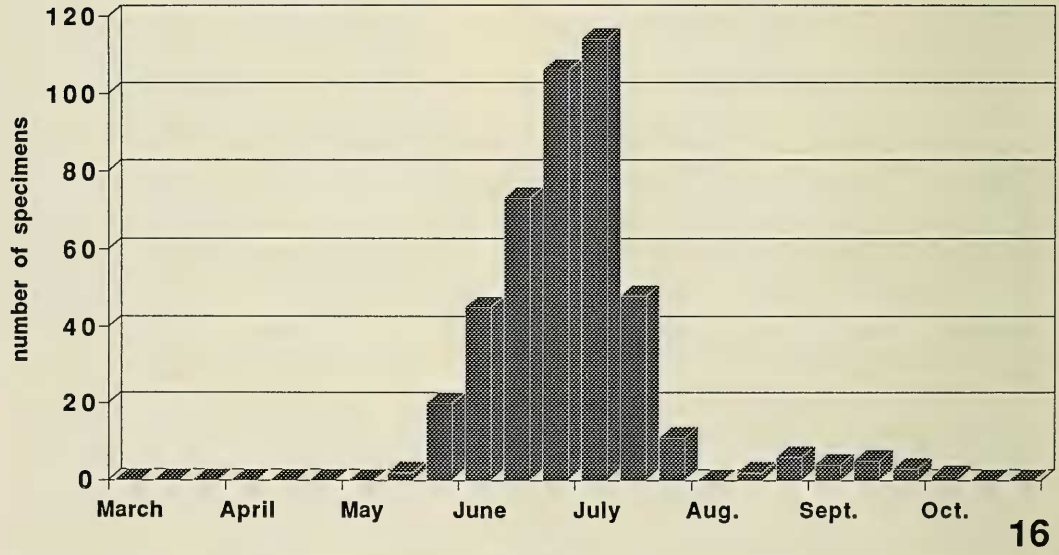


Fig. 15, 16. Cumulative flight records for all site collections, 1983–1994. 15, *Orthogonalys pulchella.* 16, *Taeniogonalos gundlachii.*

to June 5, 1991 (2) and September 23 to October 9, 1993(1), and in Allegany Co., June 10 to 20, 1992 (1) and July 20 to 29, 1992 (1).

Habitats.—Townes (1956) stated that this species occurs in more open and dry habitats than the other species. My two collection records come from traps set in dry, open situations. All specimens from Essex Co. were from one trap located in the open near a forest edge in direct sunlight most of the day. The soil is sandy in the area. The collections from Green Ridge were from traps located in openings on a shale barren where it is typically drier and warmer than the surroundings.

Association of Trigonalyidae with Sawflies

Sawflies have not been recorded as hosts in North America. However, large numbers of Trigonalyidae were collected in areas

where sawflies were also common, especially species of the sawfly genera *Taxonus, Ametastegia,* and *Macrophya* (Tenthredinidae). Most species of *Macrophya* have peak flights in June (Smith 1991, recorded seasonal flights for 28 species in Virginia), and several common species of *Taxonus* have peak flights in May to July as well as another smaller emergence peak in late August to mid-September (similar to Figs. 15 and 16). *Macrophya* are associated with several hosts, including *Sambucus* and *Prunus,* but hosts are unknown for many species. Most *Taxonus* are associated with *Rubus* and *Fragaria,* and *Ametastegia* with Polygonaceae. Many of the sawflies have not been intensively studied or reared, and their parasitoids are yet to be recorded. Even though there are many other phytophagous insects in the habitats, the similar flight times of trigonalyids and many sawflies, their presence in similar habitats, and the possibility that trigonalyid eggs remain viable for months on foliage (Clausen 1931) and are available when sawfly larvae develop, indicate that sawflies may serve as intermediate hosts.

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